INTRODUCTION TO MATHCAD

LESSON #1

Begin your Mathcad session by clicking on the Mathcad icon that is exhibited on the menu of the computers in Rickover 107, 108 & 109. When Mathcad has downloaded you will see a worksheet (the large white area) with a tool-bar directly above the worksheet. A strip of buttons is above the tool-bar and a number of pull-down menus are above the buttons. Many of the items in the tool-bar and the buttons are self-explanatory, but many perform special operations peculiar to Mathcad. You will gain experience with their use and these lessons will introduce the more common and important ones to you.

As a first exercise with the worksheet, note that a red cross (or plus) is observable in the worksheet. That is the location where operations you perform will begin. You locate this cross at other areas of the worksheet by dragging the mouse arrow and clicking left when you have located the position on the worksheet you desire, or you can use the 'Space' bar and 'Enter' key.

Let's begin with some simple arithmetic operations, using the worksheet as a calculator. Type:

20*3.3+13/8=

After you press the 'enter' key the result (67.625) is presented to the right of the '=' sign. Notice that Mathcad understands the keyboard commands '*' to mean multiplication and the '/' to mean division; however, it writes these operations with more common algebraic symbols on the worksheet. Play with some additional calculations that you define.

Now open the 'arithmetic palette' (it looks like a calculator!) from the button strip. Define some additional calculations of your choice using the 'arithmetic pallette' to define the arithmetic operation you desire. Notice that every time you insert an arithmetic operator (*, /, + or -), an open rectangle appears in the worksheet at the location where Mathcad is anticipating placing a new number. This open rectangle is called a "placeholder" and it is important to recognize its function as you begin to edit an equation later in this lesson. For now, understand that the placeholder indicates where the next number you enter will be placed in the arithmetic operations. Before you move to the next section of this lesson, try the various built-in functions that are on the arithmetic pallette and understand how they are used. (There are many additional built-in functions available in Mathcad. Those on the arithmetic pallette are among the most common. NOTE that 'log' is a base-10 logarithm. The function that defines a natural (base-e) logarithm , 'ln', is not on the pallette. Trying typing it in the worksheet directly!)

<u>DEFINING VARIABLES AND EQUATIONS.</u> Equations in Mathcad require you to define the name of one or more variables or constants. Names can include upper-case as well as lower-case letters (DIA, dia and Dia are all valid and distinct names). Names can include

numbers, the underscore _, the prime ‘ and the percent %; however, names can not begin with these characters. Names are assigned to scalars, vectors, matrices and functions. At this point we will work only with scalars. The simplest equation is one that assigns a specific value to a name. Assume that you have a name called ‘acc’ for acceleration and you desire to assign to ‘acc’ the value of -32.2 ft/sec^2. To accomplish this you type

acc:-32.2

Notice how Mathcad understands the colon. It appears in the worksheet as := ! Understand the different outcome between the keystroke for ‘=’ and the keystroke for ‘:’ . The ‘=’ tells Mathcad to EVALUATE an arithmetic or algebraic expression. The ‘:’ ASSIGNS a value to a name which may be a constant or variable in an expression. The equation for distance traveled by an object over a period of time from an initial position Y relative to a reference origin with an initial velocity of zero and an acceleration is

$$y = Y + \frac{1}{2} \times acceleration \times time^2$$

Type this into Mathcad as an equation. (Note the importance of the ‘space’ between the ‘2' and the ‘*’!)

y:Y+1/2 *acc*t^2

The result on your worksheet should include a black highlight around the ‘Y’ and the ‘t’, but no such highlight about the ‘acc’. Anytime you define an equation for which the named variables or constants have not been defined earlier, this black highlight will occur about the undefined variable or constant. (Recall you defined the acceleration, acc, to be -32.2 earlier, so it is not highlighted in black.) Now, move the Mathcad cursor ABOVE the expression that defines ‘y’, define Y to be 100 and t to be 1.5, by typing

Y:100
t:1.5

Now, evaluate the numerical value of the position, y, for these conditions by typing “y=” below the expression for y.

Mathcad will return the result ‘63.775'. Note the importance of the location in the Mathcad worksheet at which the assignment of values to Y, acc and t must adhere. FOR ANY EXPRESSION TO BE EVALUATED WITH ASSIGNED VALUES TO THE VARIABLES OF THAT EXPRESSION, THE VARIABLES MUST BE DEFINED IN A REGION ABOVE OR TO THE LEFT OF THE EQUATION TO BE EVALUATED.

REGIONS IN THE WORKSHEET. At this point it is important to observe how Mathcad blocks out "regions" on the spreadsheet. Pull down the options under the View menu and select View Regions. All of the work you have done in the Mathcad worksheet is now highlighted by darkened gray background that highlights a region about every expression. The worksheet can be returned to the default condition by repeating those steps under the pull-down View menu. You can highlight the active region about any expression of the worksheet, by dragging the mouse over the region. It will then be enclosed by a rectangle. Now you can move the region, change its size if it is a graph, and many other things that it is best to practice on your own.

EDITING. If you desire to edit an equation, you must drag the mouse arrow to that part of the equation you wish to change and click left. This will create a vertical blue bar in the equation at that position. Using the backspace key will remove items to the left of the blue editing bar and using the delete key will remove items to the right of the blue edit bar. Anything other key-strokes will be inserted to the right of the blue edit bar.

After obtaining the blue edit bar, a second click will create a placeholder (open rectangular box). Edits can then be executed within the placeholder. Notice that the placeholder can be expanded to include more and more of the equation by entering an 'up-arrow' keystroke. Create an equation of your definition and obtain experience by editing it as you wish. As a last resort for editing, the delete key can be used to eliminate a fouled-up region and you can start anew!

DEFINING A RANGE VARIABLE. You have found the result for values of the variables, acc=-32.2, Y=100 and t=1.5. Now that you have been introduced to editing in the worksheet, change the value of one or more of these variables and note that Mathcad automatically updates the regions of the worksheet that are below and to the right of the edited variable. This is a powerful tool iff you want to do a complicated calculation but change one variable.

If you desire to know the result for position, y, at a number of values for the time, t, it will be more convenient to treat t as a "range variable" rather than assigning to it a single value. In your worksheet, type

r:1;10
r=

Mathcad returns the result for r with a column of values from 1 to 10. This is known as a range variable. If you desire that the increment between the smallest and largest values be different than '1', type the second element of the sequence you desire. If you desire than r take on values between 2 and 6 with increments of 0.5, type

r:2,2.5;6
r=

The elements that define the range variable need not be positive numbers, and the range variable may be decreasing in value rather than increasing as in the examples. Define some range variables that decrease in value from the first to the last element and include some variables with negative as well as positive numbers. NOTE: Range variables are distinct and different from vectors in Mathcad. Vectors and matrices will be considered later.

DEFINING FUNCTIONS. You examined earlier how to use some of Mathcad's built-in functions that are available on the arithmetic pallette. You can define functions that are suited to the specific problem or equation you are solving. Let's return to the equation for position, y, that was defined earlier. This equation can be used to define position as a function of time, y(t) as follows. Edit the equation that defined y by simply changing y to y(t). The results on your worksheet should look like this:

$$y(t) := Y + \frac{1}{2} \cdot acc \cdot t^2$$

Now when you type 'y=' an error message is generated. To evaluate the equation, you must place a numerical value or a defined variable in place of the argument, t. For example, type

y(2)=

and you should obtain 'y=35.6' in your worksheet (assuming Y = 100).

Now create a range variable for 't' and evaluate 'y(t)'. For example, define 't' by typing

t:0,.5;2.5

Mathcad updates your evaluation for y(t) with a column table of results beginning with 100 for t=0 and ending with -.625 for t=2.5 after you type 'y(t)='.

PLOTTING. Mathcad can create plots of functions and data subject to your specifications. To create a plot with position, y(t), as the ordinate (vertical axis) and t as the abscissa (horizontal axis), begin by opening an X-Y plot graphics window. (Use the Graphing Pallette button or the pull-down Graphics menu.) When you select the X-Y plot, Mathcad opens a window in the worksheet that exhibits the x and y axes and positions a placeholder on the below the abscissa. In the placeholder of the abscissa, type 't'. Next, click on the center placeholder to the left of the ordinate. When this opens a placeholder at that location, type 'y(t)'. If you click outside of the X-Y plot window, Mathcad draws the graph. Double clicking on the area within the X-Y plot will open a set of editing windows that allows you to title the graph as well as change the color or appearance of the line plotted by Mathcad. Prepare some titles and labels of your convenience.

You can resize the graph by clicking on the black rectangle that defines the graphics

window region. Move the mouse arrow cursor down to the lower right corner of the region. This will highlight a double-headed arrow. Drag this arrow in the direction you desire to enlarge or shrink the region for the graphics window. Experiment with some of the other features of plotting. What if you only wanted to plot points rather than a line between the points?

DEFINING VECTORS AND MATRICES. Vectors and matrices are defined by first telling Mathcad the size of the matrix. Matrices of one column (column vector) or one row (row vector) are vectors; however, Mathcad recognizes common vector operations only on the column vector or the 'n x 1' matrix. Names are assigned to vectors and matrices just as discussed above. In order to specify the size of the matrix or vector, use the Math pull-down menu or use the matrix button to open the matrix pallette. For example, after typing the name and the colon operator, select the 'matrix' icon from the pallette and a window opens in which you can specify the size of the matrix or vector. Define two 3-element space vectors "**A**=3i+4j+6k" and "B=10i+5j+8k". Type

A:

open the matrix pallette, and specify a matrix of 1 row and 3 columns. A three element blank '1 x 3' matrix (row vector) will open on your worksheet with a placeholder at the first element. Enter '3' and use the 'Tab' key to move to the second element. Enter '4' and use the 'Tab' key to move to the third element. After you define B in the same manner, try the vector scalar (dot) product, again using the matrix pallette. Note that an error is generated because you are attempting to perform a vector operation on a row vector. If you redefine the row vectors by taking their transpose

$A:=A^T$ and $B:=B^T$

the scalar product will give you the result of '98'. Of course you could have defined A and B to be '3x1' column vectors when you created the original matrix! Now that you have defined A and B as column vectors, find their vector (cross) product. You should obtain AxB = 2i + 36j - 25k. We will look at more matrix operations later.

MEAN VARIANCE AND STANDARD DEVIATIONS. To find the mean and variance of a set of numbers, enter them into a Mathcad worksheet as a vector. Because evaluating the mean is an arithmetic operation and not a vector operation, the vector can be a row or a column vector. The built-in Mathcad functions that evaluate mean, standard deviation and variance are

mean(x) stdev(x) var(x)

Define a set of numbers of 10 or more elements, enter them into a Mathcad vector and find the mean, standard deviation and variance.

SAVING RESULTS. You can save a Mathcad worksheet by simply pulling down the File menu and selecting the "Save As' option. Remember you are running Mathcad on a network with a

common disk storage. If you desire to save anything you should have it saved to your disk on drive ‘a’. It is probably best to use the default extension of “.mcd” when naming files.